Technical Evaluation Report

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Opening remarks were provided by Professor Braga Costa Campos, CDR Leite, and Dr. King.

Session 1 was classified, and began with a presentation by Weatherington on various platforms in use by the US DoD, their signal collection types (described as EO & IR, although IR in general is considered an EO technology, so EO may refer to visible in this case), and growth plans for future capabilities. Fenner Milton then presented on tests by the US Army Night Vision and Electronic Sensors Directorate obtained with a small UAV test surrogate that incorporated a body-mounted sensor and uncooled IR imager. As part of questions and answers, it was stressed that these short range, low altitude observations are compatible with low levels of magnification (large FOVs) and the body-mounted approach. However, higher altitudes would require higher magnification and sensor stabilization to maintain regions of interest in the smaller fields of view. The third presentation (by Marchal) was an interesting overview of an operational group's results in combining capabilities of a higher altitude, piloted F16 with lower altitude UAV sensing capabilities. Such a combination was shown to enhance the relevance of the imagery collected from the UAV. In the fourth paper (by Fetrow), the results of polarimetric data collections were showcased, principally in the LWIR. Key results were presented in which it was seen that certain combinations of sky brightness (reflected from the scene) and target observation angles can mask the useful polarimetric information. This limitation can be overcome in part by emphasizing LWIR over MWIR measurements. The next paper (by Hintz) described a broad range of active and passive considerations for UAVs in support of the Navy. Active sensors included both laser and SAR imagery. A comparison of infrared wavebands for various atmospheric conditions was described for this Naval application.

Session 2 began with an overview by Fiamingo of the SET (sensors & electronics technology), of the NATO RTO (research and technology organization) which now involves approximately 22 nations, 6 or 7 panels, and approximately 46 panel members. The SET is further divided into RFT (radio frequency technology), OT (optics technology), and MSE (multi sensors and electronics). The PfP (partners for peace) now includes about 20 countries, and has existed since 1992. The second presentation (by Vitko) described various algorithmic approaches for neural fusion and classification in the contexts of robots and robotic sensory data. An example was provided in terms of decomposing the motions of a walking robot. For such a robot, monitoring the degradation (e.g., increased friction or degraded actuator performance) experienced in joints associated with critical motions in walking can lead to an early prediction of an otherwise unanticipated malfunction, with the prospects of improved robotic performance over time. The third paper (Cardou) considered the question of replacing angular rate sensors with accelerometers distributed over the body of a UAV. The time integral of the resulting accelerations was studied in detail, first with an essentially "brute force" integration of the measured acceleration (with the inherent sensor drifts) as a function of time. Next, the special case of centripetal motion associated with a circling UAV was considered. In this case, the integral of the accelerometers signals proved competitive with that of the angular rate sensors over longer times, but still

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too short at present to be of practical value. The next paper (Mahalu) described details on electrical data buses and on the synchronization of peripherals communicating over the bus and resulting arbitration of potential conflicts that would be of interest for multi-sensor operation. Radio channel communication was considered in detail. In the paper by Sirieix, testing results obtained with a Sagem tactical UAV system (catapult launched, parachute recovered), used by the French, Dutch, and other armies, were described. The following presentation was closely related to the Sirieix presentation, with the velocity field of "optical flow" considered for scene components with brightness changing with time, due either to intrinsic variation or motion relative to the scene background. An impressive use of super resolution was described that sharpened the resulting imagery considerably. The next paper (Echard) discussed results in using an 8 to 12 micron line scanner and laser range finder and designator on a four-axis stabilized platform. Five types of UAV platforms were utilized, one of which having VTOL (vertical take-off and landing) capability. The miniaturization of both the rotating sensor "balls" and the sensors themselves was required to support these tests. The third-to-last paper of the session (Decuypere) described smaller, less expensive UAVs that would provide assets to soldiers at the lower-than-battalion level. The Mirador supports an approximate 35 gram payload mass, the Sparrow a 500 gram mass, and the quad-helicopter also a 50 gram mass. These platforms exist and have been proven to function but they await sensor payloads having the appropriate low masses for integrated testing. The penultimate paper of the session (Tien Pham) represented a departure from the principally EO emphasis of the presentations up to this point by focussing on acoustic detectors for sensing other UAVs in the balttlespace. Data of this type were collected for seven types of UAV, running the gamut from tactical to non-tactical and gas to electric power. The final paper (Pavlovsky) described acoustic sensors in the context of mobile robots. Two such sensors allow the robot to listen, move over a specified distance, and stop to listen again, with the process repeating. The conclusion is that the "phase discriminator" method works well for describing the processing of auditory information by robots.

Session 3 began with a presentation (by Lavigne) on emulating the favourable properties of human sight in the context of a wide field of view, IR sensor. Initial tests aboard a helicopter made use of an 8 to 9.2 micron camera (quantum well infrared photodetector and Indigo Phoenix camera), and was impressive in combining high resolution with large field of view imaging through a fast and high fidelity mosaic process. The second paper (de Lange presenting for den Breejen) described an effort to identify, from UAV platforms, areas on the ground most likely to benefit from de-mining efforts, with practical experience gathered from actual de-mining efforts in the Balkans. Various forms of imaging enhancement were employed to color code potential mine fields. The conclusions emphasized that good image processing with lower quality (more economical) infrared cameras can lead to satisfactory image products. The third paper (Richmond) described a polarimetric, imaging laser radar working at a wavelength of 1.06 micron. Terrain and foliage obscures targets, and the range-gated approach employed was shown to allow for the identification of man-made objects behind the foliage. The fourth paper (LeVan) described an approach for obtaining spectral imagery over a broad range of infrared wavelengths with high efficiency, and with a single grating element and dual-waveband focal plane array. Such an approach extends the spectral range of dispersive spectrometers to several octaves of wavelength, and preserves alignment of the spectral image over the full range of wavelengths. The penultimate paper (Thoennessen) presented the analysis of imagery obtained from a Piper aircraft configured for remote piloting. Two sensor array types were used, one a silicon microbolometer array working in the 8 to 14 micron region, the other a quantum well infrared photodetector (QWIP), with spectral response in the 8 to 9 micron range. A laser operating at a wavelength of 1.56 microns and scanning at 653 lines per second was also employed. Useable imagery was retrieved from the un-stabilized flight and uncompensated sensor pointing, with a combination of scene mosaics and self-calibration of sensor pointing direction. A "correlation tracker" for objects moving in the scene was successfully implemented, with the conclusion that the combination of laser, visible, and infrared aids greatly in achieving the desired level of CROP (current, relevant operational picture). The final paper of the session (Buss) described a concept for

protecting Navy sea-based assets with a constellation of 3 or 4 circling UAVs. Sensors of interest included SAR and infrared imagers, whereas active millimetre wave was found to have insufficient resolution for the application. Good coverage and a rapid revisit rate was obtained for distant targets (small boats), seen as point sources of infrared emission. The relative benefits of MWIR and LWIR for this application were compared, with the preference expressed for MWIR if supplemented with a spectral notch filter for removal of a range of MWIR wavelengths suffering from poor atmospheric transmission.

Session 4 began with a paper (Morrison) describing an interesting concept for the "thinning" (or reduction) of discrete frequencies transmitted by a frequency agile SAR. In this approach a continuous-wave SAR transmits, receives, and processes each frequency prior to transmitting the next higher frequency, and the entire process is repeated periodically. Overall performance parameters include 10 cm resolution, 10 GHz operation, a platform speed of 35 m/sec, and a 10-degree beam width. The proposed approach was found to preserve resolution (in terms of the beam width of the transmitted wave), with only signal level suffering by the random removal of various frequencies during the transmission. The next paper (Rossum) described a developmental effort for a small, phased array SAR for moving target identification that would provide polarimetric capability in the C Band (5.3 GHz). The conclusion supports the use of many commercially-available components to realize the capability in a cost-effective way. The next paper (Marques) was the first of a series on RF sensing, and began with a theoretical overview relating the blind angle ambiguity with SAR. Transformations allowed the problem to be recast in one-dimensional formulation. Using the Maximum Likelihood method for estimates of moving target parameters (position, velocity), the conclusions were that all relevant parameters of interest could be obtained with a single SAR, and the blind angle ambiguity removed. The next paper (Jeuland) explored new RF concepts for supplementing EO on UAV payloads by first concerning itself with issues of down looking radar and secondly with the problem of RF antennas affected by vibrating platforms. Radar geometrical distortion was described. Beam forming and SAR lead to a "3-dimensional radar image" (vehicle height profiles). Flight measurements are possible with a motor glider supplemented with payload pods, with such tests planned for the end of the year 2005. Areas of emphasis to mitigate the expected disruption caused by motion of the transmitting arrays include active vibration control, mechanical and or electrical compensation, or signal processing approaches. The next paper (Hoogeboom) explored "frequency domain delivery of signal", and selected a miniature SAR operating in continuous wave and frequency modulated modes. It was pointed out that coherent pulse Radars were of lesser interest for the application, due to cost and size/weight/power issues. The proposed concept can be flown on motor glider or ultra light aircraft. Its P Band frequency embodiment is appropriate for forest "state of health" monitoring as well as de-forestation surveillance. So far, Ka Band has been successfully tested, and P Band will soon emerge from the design and development stage. The penultimate paper (Morris) presented the I-Master concept for a compact, high performance Radar, currently in the design phase. The Ku band was selected over the Ka band for improved all-weather performance, and the Radar is being designed to have SAR and GMTI modes. The platform targeted for the application is a "small tactical UAV" with an approximate 30 kg payload capacity. An approach for "coherent change detection" was described; it exploits measured phase differences in the received signals. The multi-phase center antenna that is employed is expected to provide improved clutter rejection. The last paper of the session (Mathews) described low-cost, lightweight, multi-beam antennas for UAVs, with a goal of achieving an "electronically switched" capability for time delay. Trade-offs were presented that resulted in the selection of a Luneburg lens. The conclusions were that the Luneburg lens proves to be a suitable alternative to phased array, and the results of assembling a communications demonstration based on these concepts were described as favourable.

A summary was provided by Dr Buser at the end of the formal presentations.

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